Sensor and stabilized platform

PATENT SPECIFICATION

(11) 1 484 185

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(21) Application No. 46728/74 (22) Filed 29 Oct. 1974
(31) Convention Application No. 15914/73
(32) Filed 13 Nov. 1973 in
(33) Switzerland (CH)
(44) Complete Specification published 1 Sept. 1977
(51) INT CL² B65H 23/18
(52) Index at acceptance
G3N 251 265A 287 371 BRX

(19)

(54) APPARATUS FOR INTRODUCING A STRIP OF PAPER, CARDBOARD OR SIMILAR WEB MATERIAL INTO A PRINTING MACHINE

(71) We, J. BOBST & FILS S.A., a Swiss Body Corporate of Route de Renens—1008 Prilly, Switzerland, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to apparatus for introducing a strip of paper, cardboard or other similar web material into a printing machine in such a manner as to optimize the format control of the machine.

For the purpose of introduction of a web of paper into a printing machine, an introduction unit is used, the function of which has hitherto been restricted to isolating more or less effectively the printing units from the perturbations which could originate in an unreeler. Its effect is therefore comparable to the part played by a filter, which suppresses or reduces the propagation of variations in tension from the unreeler towards the printing units. Such an introduction unit does not, however, meet the needs of modern rotary printers. Indeed, since a web must be treated after printing, either in line with the rotary printing press or on a separate machine, a format control is required which will ensure subsequent treatment under the best possible conditions. When the web is intended for insetting, that is a web pre-printed in helic is then introduced into a rotary printing press for reprinting, the web is subjected to a certain tension during reprinting, in such a manner that it is desirable to ensure a constant format under a determined tension.

According to the invention, an apparatus for feeding a web of material to a printing machine comprises electro-mechanical means for setting the tension of the web being fed to the printing machine in response to a supplied tension-value signal; means for providing an electrical signal which corresponds to a continuous measurement of the coefficient of elasticity of the web; and means for supplying said tension-value signal, as a function of the signal which corresponds to the measurement of the coefficient of elasticity, to said electro-mechanical tension-setting means.

Preferably the means for providing the electrical signal which corresponds to the continuous measurement of the coefficient of elasticity comprise means for applying a specific elongation to a section of the web being fed, and means for continuously measuring the change of tension produced in said section of the web by said specific elongation. An arrangement of this type for the continuous measurement of the coefficient of elasticity of a moving web or strip is described and claimed in U.K. Patent Application No. 1,471,997.

The accompanying drawings show, by way of example, an embodiment of the invention. In the drawings:

Fig. 1 is a diagram of the apparatus; and

Figs. 2 to 5 are diagrams of parts of the circuitry of Fig. 1.

Fig. 1 diagrammatically shows a web of paper 1 coming from a reel and being unreeled in the direction of the arrow F_1 so as to be introduced into a printing unit, not shown. Web 1 is drawn along by a mechanical arrangement comprising a first traction roller 2 of radius R_1 cooperating with a pressure roller 3, and a second traction roller 4 of radius R_2 cooperating with a pressure roller 5. The traction rollers 2 and 4 are driven at the same angular velocity by a d.c. motor 6 having a constant field excitation structure 7. The armature 8 of motor 6 is fed by a static feed comprising a loop 9 controlling the armature current. The loop 9 is closed through an operational amplifier 10 which has an input 11 which may be energized with a value corresponding to the desired driving torque and provided by a calculator 27.

The web 1 also passes over a fixed axis pulley 12, under a pulley 13 of a first device 14 for measuring the web tension before the first traction roller 2, and under a third pulley 15 of a second device 16 for measuring the web tension before the second

traction roller 4. The devices 14 and 16 are known *per se* and include means for providing an electrical quantity proportional to the mechanical tension exerted on the web.

The web 1 then passes over a fixed axis pulley 28 and then under a movable pulley 29 mounted on a lever 30 provided with a movable counterweight 31, and over a fixed axis pulley 32 before entering the printing unit. The movable pulley 29 and counterweight 31 are for the purpose of applying to the web 1 a set tension calculated by means of circuit which will be described later. The counterweight 31 is driven along lever 30 by an electric motor 33 and is fixed with the slider 34 of a variable resistor 35. A device 36, fixed for movement with the slider 31, provides an input value for the calculator 27.

The various parameters of the web feed are defined as follows:

- l is the length of web 1 between rollers 2 and 4;
- v is the velocity of the web 1 as it passes over roller 2;
- x is the distance travelled by the web 1 in a time $t(x=vt)$;
- T designates tension, T_1 and T_2 being the mechanical tensions measured by devices 14 and 16 respectively;
- K' is the uncorrected coefficient of elasticity of the web 1, measured in static conditions;
- K is the coefficient of elasticity of the web 1 measured in dynamic conditions;
- τ is a time constant which is a function of the speed v, given by $\tau(v)=l/v$; and
- L is the free length of web 1 between the introduction unit (roller 4) and the first printing unit.

The apparatus also includes: a device 17 which introduces a time constant according to the function $1-e^{-x/l}$ to which are delivered firstly the electrical value provided by the measuring device 14, and secondly an electrical value proportional to the velocity v of the web; a circuit 18 comprising an operational amplifier to which are applied both the electrical quantities delivered from the devices 16 and 17 and delivering a signal proportional to the difference of these electrical quantities; and a multiplier circuit 19 with an output giving an electrical quantity proportional to the coefficient of elasticity of the web.

Radius R_2 is slightly greater than radius R_1 by about one part in a thousand. Since the angular velocities of the traction rollers 2 and 4 are strictly identical, this difference in radius leads to an increase in web speed of 0.1% between the traction rollers 2 and 4, that is to a fixed increase in the specific elongation of the web of $(R_2-R_1)/R_1$.

The uncorrected coefficient of elasticity K' is equal to the ratio "increase in tension/increase in elongation" in the stationary state. It is given by:

$$K'=\frac{(T_2-T_1)}{(R_2-R_1)}.R_1$$

In dynamic conditions, it is necessary to have regard to the fact that a variation in the web tension T_1 does not have an immediate effect on tension T_2, but that there is a "time constant" due to the spacing between the two pairs of traction-pressure rollers.

A perturbation ΔT_1 of the tension T_1 causes a perturbation ΔT_2 in tension T_2 in accordance with the equation:

$$\Delta T_2(T_1)=(1-e^{-x/l}).\Delta T_1$$

Therefore, to make a valid comparison between the two sets of information provided by the tension measurement devices 14 and 16, the measurement of device 14 is subjected, by electronic means, to an attenuation function or correction factor compensating for the time lag in the variations of tension T_1 before reaching the level of T_2.

On introduction of this correction factor, we obtain a measurement of the coefficient of elasticity K in dynamic conditions:

$$K=\frac{T_2-T_1(1-e^{-x/l})}{(R_2-R_1)}.R_1$$

We thus obtain a continuous and exact measurement of the coefficient of elasticity for whatever variations may take place in tension T_1. This definition, as a function of a length (l) can also be computed as a function of time, since

$$1-e^{-x/l}=1-e^{-vt/l}=1-e^{-t/\tau}$$

Circuit 17 produces exactly the function $1-e^{-x/l}$ as a function of the speed v of the web measured by a tachymetric device. Circuit 18 produces an electrical value proportional to:

$$T_2-T_1(1-e^{-x/l})$$

and circuit 19 multiples this value by a factor proportional to

$$R_1/(R_2-R_1).$$

Knowing the coefficient of elasticity K, it is possible, by multiplying by a set elongation, to obtain a tension. This is effected by a multiplier circuit 37 to which is fed both the value proportional to K from circuit 19,

and a value $\Delta l'_c$ from a circuit 38 to which is fed, by means of a potentiometer, a set elongation Δl_c. Circuit 38 compensates for the non-linearity of the tension-elongation relationship $T=f(\Delta l)$ for the web material being fed.

At the output circuit 37 is obtained a value proportional to a tension T''_{3c} to which a tension T_c determined by a potentiometer 40 is added by means of a circuit 41. At the output of circuit 41 is thus obtained a tension value given by the relationship:

$$T'_{3c}=l'_c \cdot K+T_c$$

In order to apply this tension to the web it is necessary to have regard to the lag corresponding to the free length L of the web between the introduction unit and the first printing unit. To allow for this length L a pure delay is introduced by means of a circuit 42 which introduces a delay according to the function e^{-sL}, where s is a function depending on the web velocity, a value corresponding to L being supplied by an adjustable potentiometer 43.

Since this delay must also be a function of the web speed, this variable v is introduced into circuit 42 at 44'. At the output of circuit 42 we obtain a tension T_{3c} given by the following relationship:

$$T_{3c}=T'_{3c}e^{-sL}$$

The set tension T_{3c} so obtained is applied to the web by means of movable pulley 29 and its counterweight 31 by means of an operational amplifier 44, to the input of which are applied set tension T_{3c}, a minimum tension T_{min} corresponding to the minimum tension which can be obtained with the movable pulley 29, with the counterweight at position "0", and a value y corresponding to the position of the counterweight 31, that is to say of slider 34 on resistor 35. The values T_{min} and y are subtracted from T_{3c}. The output current from amplifier 44 feeds motor 33 which moves the counterweight 31. Therefore, to a given tension T_{3c} there corresponds a well determined position of the counterweight, given by the relationship:

$$y=g(T_{3c}-T_{min}),$$

where g is a function related to the characteristics of lever 30 and weight 31.

The use of a movable pulley for applying tension to the web has many advantages. It allows friction to be reduced to a minimum. In place of the lever 30 shown in Fig. 1, it is possible in particular to use an articulation with crossed blades. The effect of the angular position of the movable pulley with respect to its axis of articulation 45, on the resultant tension is small. This effect can in addition be limited by increasing the lengths of the parts of the web 1 between the pulley 29 and pulleys 28 and 32. The tension exerted on the web being dependent on the lengths of the lever arms, it is possible to have a high tension in the web while still retaining a relatively low mass for the movable pulley-counterweight assembly. Finally, control of web tension is effected solely by adjustment of the position of the mobile counterweight 31.

The position of pulley 29 is measured by detector 36 which produces an electric value which is fed into PID calculator 27. In order to prevent any damping at the level of the pulley 29, and so as to limit to the minimum variations in web tension during displacement of pulley 29, it is preferable to introduce a differential term with a significance of the order of half the significance of the proportional term given by the pulley position. This differential term is given by a tachymetric generator 46 mounted with a position-indicating potentiometer 36 on the pivot axis 47 of the pulley 29. Thus the true derivative of the position, that is the rate of angular displacement of the movable pulley assembly is obtained. It is, of course, equally possible to calculate the differential term by analogue means. The gains of the different terms of the PID calculator 27 are determined by simulation technique starting from important mechanical values such as inertias, masses, exact course of the pulley, etc.

The circuit 17 providing the function $1-e^{-vt/n}$ is shown in Figs. 2 and 3. This arrangement is composed of an integrator 20, a precision servopotentiometer 21, an operational amplifier 22 and an electronic divider 23 which provides the reciprocal of a value proportional to the speed v given by a tachymetric generator 24. The various elements of the circuit are known as such and are commercially available. Circuits 22 and 23 are integrated. The servopotentiometer 21 include a motor 25 which simultaneously drives the sliders of three variable resistors Z_0, Z_1, and Z_2. The variable resistor Z_0 connected between a positive supply and earth has its slider linked to one of the inputs of the operational amplifier 22, the other input of amplifier 22 being constituted by a voltage proportional to $1/v$ provided at the output of circuit 23.

The variable resistors Z_1 and Z_2 are respectively connected in series and in parallel with the operational amplifier 26 of integrator 20, as is more clearly seen in the electrical circuit of Fig. 3. A capacitor C is connected in parallel with resistor Z_2. An electrical value proportional to the mechanical tension T_1 is applied to the other terminal of the variable resistor Z_1 whereby the circuit delivers the function

$$T_1(1-e^{-t/\tau})$$

i.e.

$$T_1(1-e^{-x/l}).$$

Since the constant τ is proportional to Z_2, and Z_2 varies with $1/v$, we obtain the desired function.

Figure 4 shows circuit 38 reproducing the function

$$\Delta l'_c = F(\Delta l_c).$$

Circuit 38 is a diode function generator as is currently used in analogue calculations. It comprises an operational amplifier 48 in series with a resistor Z_{10} and in parallel with three resistors Z_{11}, Z_{12} and Z_{13}, the resistors Z_{12} and Z_{13} being themselves each in series with a respective Zener diode D_1 and D_2. Initially only resistor Z_{11} is in circuit, then when the voltage proportional to Δl_c applied to the circuit input increases the Zener diodes D_1 and D_2 successively become conducting and the resistors Z_{12} and Z_{13} are successively brought into circuit, which changes the slope of

$$\Delta l'_c/\Delta l_c$$

Fig. 5 shows circuit 42. It comprises a cascade of analogue memories 49, a circuit which is commercially available in integrated form, a voltage-frequency converter 50, constituted by a pulse generator and a flip-flop 51 controlled by the converter 50 and with its outputs Q and $\overline{Q}$ applied to transistors Tr_1, Tr_2, etc. of the cascade of analogue memories 49 in such a manner as to transfer the information from one memory to the other at the frequency of the pulses received. This frequency is the frequency of the pulse generator 50 which is made proportional to the web speed v and inversely proportional to the length L. For this purpose, the voltage proportional to the web speed v as applied to circuit 17 is also applied to converter 50 via a resistor Z_4. A voltage corresponding to length L is given by the potentiometer 43 already mentioned.

The use and advantages of the equipment will be illustrated by some examples.

Example 1

It is required to carry out an introduction at constant elongation. The engraved cylinders of the rotary printing press have a circumference of 1000 mm and it is required to obtain a 998 mm format at zero tension, that is to say web at rest. Such requirements exist at present when the final format is important (conventional platen, draft printing, etc.).

$$(R_2-R_1)/R_1=0.001$$

is chosen.

Given that a 998 mm format at zero tension is sought, the elongation Δl_c to be obtained is 2 parts in 1000. Since this elongation is desired starting from a web at rest, the tension T_c to be supplied by potentiometer is 0. In this case, the set tention T_{3c} is proportional to the measured coefficient of elasticity.

Example 2

It is required to introduce the web subjected to the set tension T_{3c}, for use of the web in a printing machine at constant elongation under a determined tension. This is the case, for example, for insetting or for a rotary cutter.

Suppose that the circumference of helio cylinders of the printing machine is 1000 mm, that of typographical cylinders is 997 mm and the unwinding tension on a typographic unwinder is 25 kg, the following values of the settings must be used:

$$\Delta l_c = 3 \text{ parts in } 1000$$
$$T_c = 25 \text{ kg}$$

Thus, the 997 mm format must be obtained under a tension of 25 kg since the web is subjected to that tension after its introduction into the printing machine. It follows from the preceding formulae that in this case the set tension T_{3c} no longer varies in direct proportion to the coefficient of elasticity, but is also a function of the reference tension T_c.

Example 3

If a feed at constant tension is required, the elongation is set to 0 and the tension T_c is set to the required value. With this setting, the apparatus operates in the same manner as a conventional apparatus.

In general, the length of the format L' is determined by the following relationships where C is the circumference of the cylinder.

$$L' \text{ (at rest)} = C(1-\Delta l_c - T_c/K)$$

$$L' \text{ (under tension)} = C(1-\Delta l_c).$$

WHAT WE CLAIM IS:—

1. An apparatus for feeding a web of material to a printing machine, comprising electro-mechanical means for setting the tension of the web being fed to the printing machine in response to a supplied tension-value signal; means for providing an electrical signal which corresponds to a continuous measurement of the coefficient of elasticity of the web; and means for supplying said tension-value signal, as a function of the signal which corresponds to the measurement of the coefficient of elasticity, to said electro-mechanical tension-setting means.

2. An apparatus according to claim 1, in

which the means for providing the electrical signal which corresponds to the continuous measurement of the coefficient of elasticity comprise means for applying a specific elongation to a section of the web being fed, and means for continuously measuring the change of tension produced in said section of the web by said specific elongation.

3. An apparatus according to claim 1 or 2, in which said supplying means comprises means (39) for providing an electrical signal representing an elongation value, means for combining the electrical signal corresponding to the continuous measurement of the coefficient of elasticity with the elongation-value signal to provide a first tension-value signal (T_{3c}''), means for providing a reference tension signal, and means for adding the first tension-value signal and the reference tension signal to provide a second tension-value signal (T_{3c}) which is delivered to said electro-mechanical tension-setting means.

4. An apparatus according to claim 3, wherein said combining means is a multiplier and comprising, between the means (39) for providing the elongation-value signal and the multiplier, means for introducing a compensation for non-linearity of the tension-elongation relationship of the web material.

5. An apparatus according to any preceding claim, wherein said supplying means comprises means for introducing a delay in the delivery of the tension-value signal to the tension setting means to allow for the length of the web between a location where its coefficient of elasticity is measured and the printing machine.

6. An apparatus for feeding a web of material to a printing machine constructed and arranged to operate substantially as described with reference to and as shown in the accompanying drawings.

MARKS & CLERK,
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1 484 185 COMPLETE SPECIFICATION
3 SHEETS

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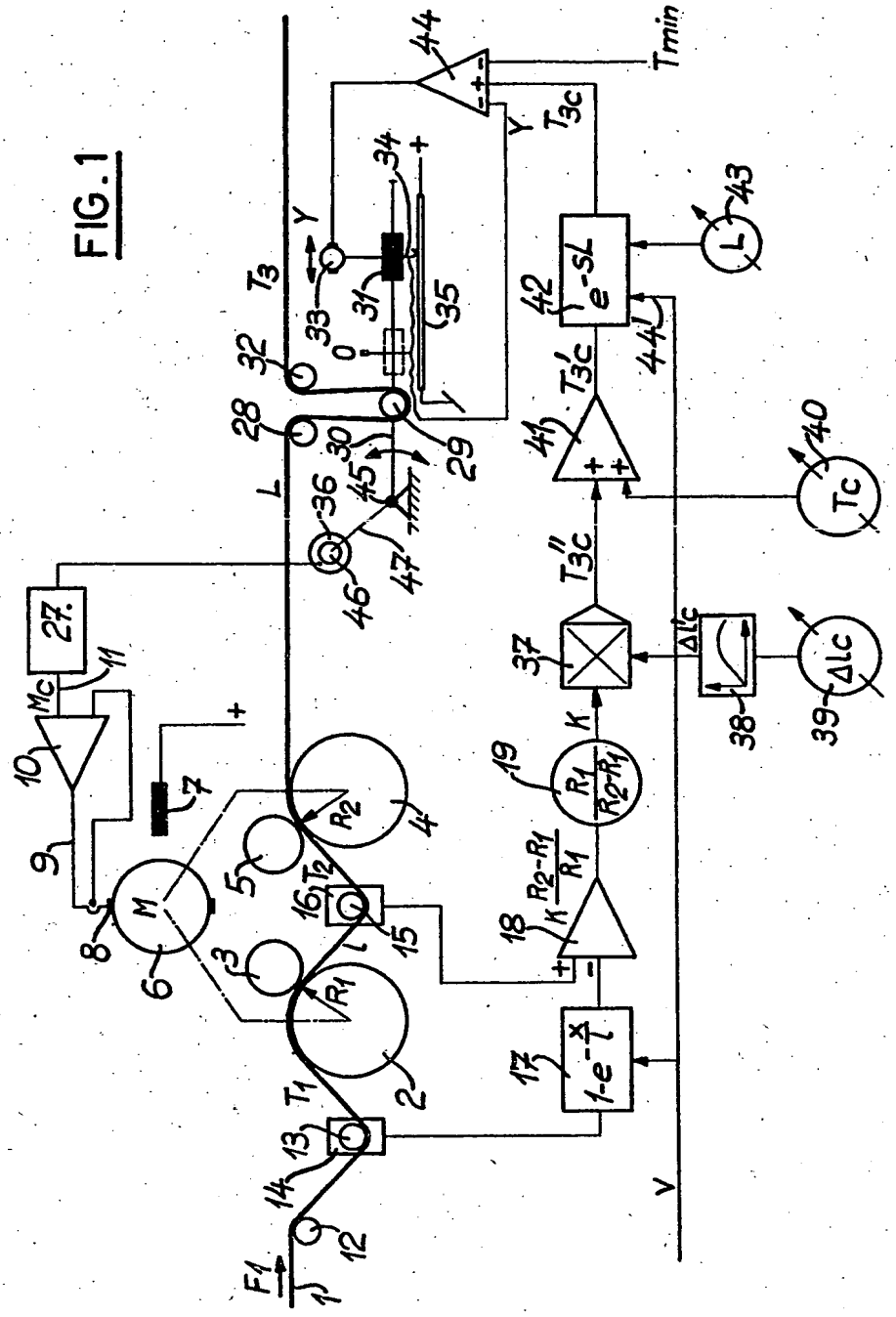
SHEET 1

FIG. 1



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3 SHEETS

COMPLETE SPECIFICATION

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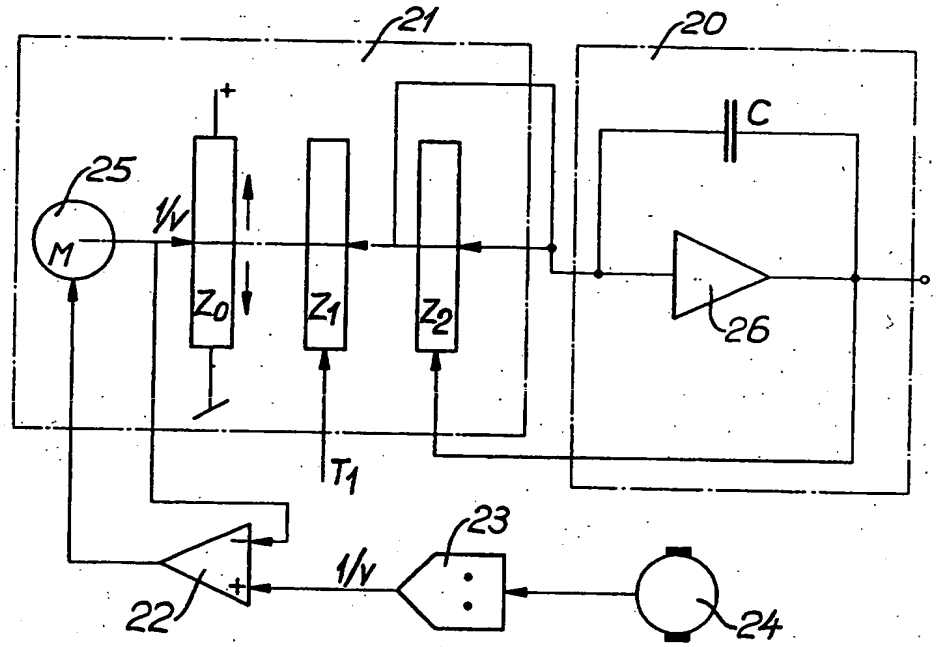

FIG. 2

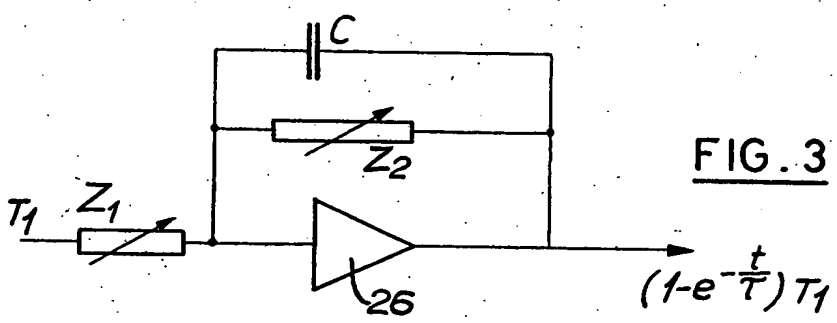

FIG. 3

1484185 COMPLETE SPECIFICATION
3 SHEETS
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SHEET 3

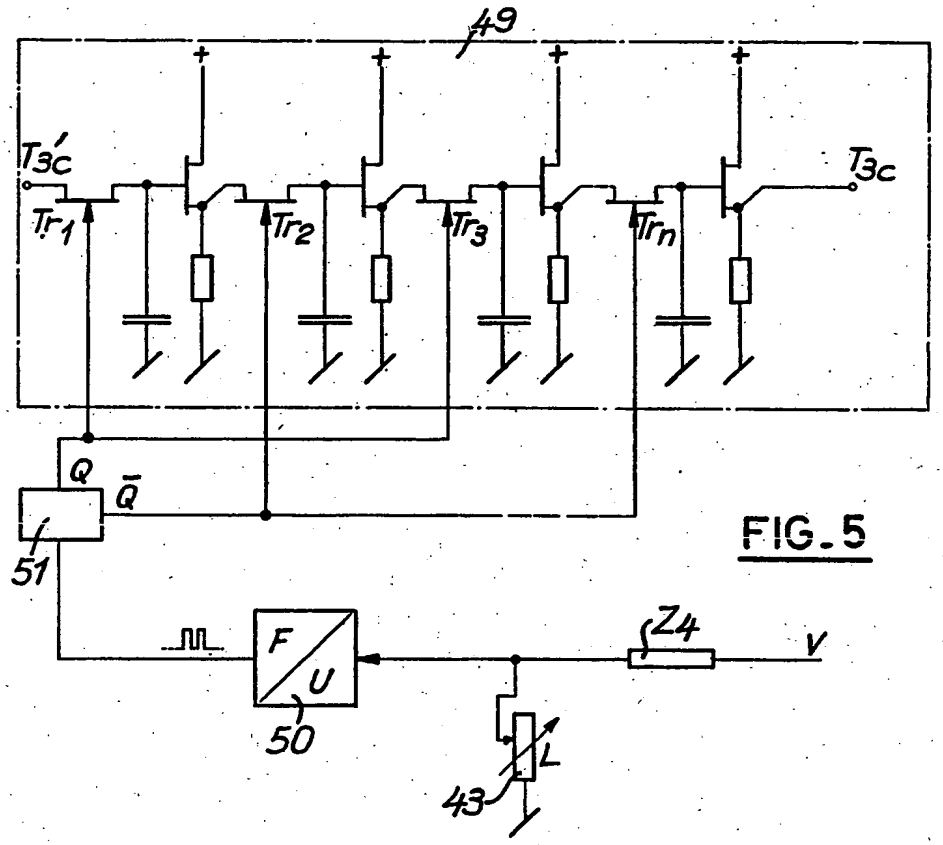

FIG. 5

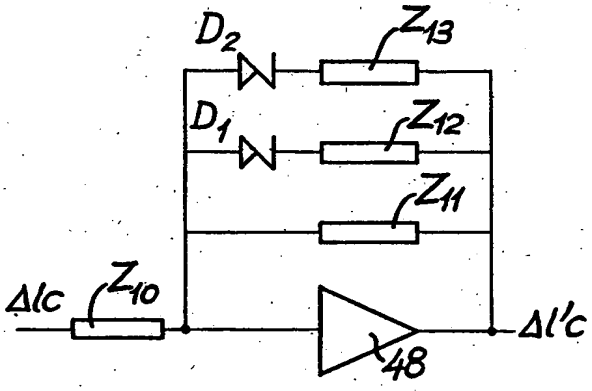

FIG. 4